An updated assessment of the Agulhas sole resource, *Austroglossus pectoralis*

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Summary

This analysis updates that of Butterworth and Glazer (2014), which considered two hypotheses of decreasing catchability and of decreasing productivity to account for a recent large drop in CPUE. Two further years of data reflect some increase in CPUE. For the most pessimistic scenario (a decrease in productivity, which remains at its current reduced level into the future), projections are somewhat more positive than previously, with recent biomasses estimated higher and projected to decrease more slowly if the 2013 effort level is maintained.

Introduction

A simple form of the dynamic Schaefer model was applied to assess the sole resource in 2014 (Butterworth and Glazer, 2014). Two hypotheses were postulated to address the decline in CPUE since 2009, namely that this was a result of decreased catchability or alternatively a result of reduced productivity. An additional two years of catch and CPUE data are now available, and the results from an updated assessment which takes these into account are reported here.

The data

The annual catch series and CPUE index used in the assessment model are reported in Table 1 and cover the period 2000-2015. The catches relate to the total sole catch made per annum, while the standardized CPUE index relates to that of Model Cb in Fairweather *et al*. (2016), reflecting a CPUE index derived from data for seven sole specialist vessels in six of the nine grid blocks that comprise the sole grounds, where these data are further restricted to sole targeted fishing only. It should be noted that there has been an upturn in CPUE since 2013.

The assessment model

The dynamic Schaefer model (adopted here for its simplicity) is of the form:

$$B_{y+1} = B_y + rB_y[1 - \frac{B_y}{K}] - C_y \qquad (1)$$

where

B_y is the biomass estimated in year *y*, with the starting biomass B_{2000} assumed to be at the MSY level $K/2$,
r is an estimable parameter (the intrinsic rate of population growth), which for realism was constrained to lie in the range [0.4; 0.7].
K is pristine biomass set at $800/(r/4)$, i.e. the MSY is assumed to be 800 tons (an amount landed regularly in the past), and
C_y is the annual catch.

The likelihood is calculated assuming that the abundance index (CPUE) is log-normally distributed about its expected values:

$$I_y = q_y B_y e^{\varepsilon_y} \tag{2}$$

where I_y is the abundance index for year *y*, $q_y B_y$ is the corresponding model estimate (q_y being the estimated year-dependent catchability coefficients), and ε_y is the observation error, $\sim N(0, \sigma^2_{cpue})$, in year *y*.

The contribution of the abundance index to the negative log-likelihood function (after the removal of constants) is given by:

$$-\ell nL = n\ell n\left(\hat{\sigma}_{cpue}\right) + \frac{n}{2} \tag{3}$$

For the assessment conducted in 2014 two hypotheses were considered to explain the decline in CPUE experienced since 2009. These were as follows:

- Hypothesis 1: assumes that catchability decreased over the period 2009-2013. Given the upturn in CPUE since 2013, the assumptions made for the year-dependent q_y have been revised as shown below in light of the additional data now available:

  q_y is defined as qZ_y, where:

  - Z_y=1 for y≤2010,
  - $Z_{2011} = 1 - \mu$,
  - $Z_{2012} = 1 - 2\mu$,
  - $Z_{2013} = 1 - 4\mu$,
  - $Z_{2014} = 1 - 3\mu$, and
  - $Z_{2015} = 1 - 2.5\mu$

  μ is assumed to be 0.2.

- Hypothesis 2: assumes that productivity decreased over the period 2007-2013. Given the upturn in CPUE since 2013, the assumptions made for the year-dependent r_y and K_y parameters have been revised as shown below in light of the additional data now available:

  r_y and K_y are defined as rU_y and KU_y, where:
  - U_y=1 for y≤2007,
  - $U_{2008} = e^{-\delta}$,
  - $U_{2009} = e^{-2\delta}$,
  - $U_{2010} = e^{-3\delta}$,
  - $U_{2011} = e^{-4\delta}$,
  - $U_{2012} = e^{-5\delta}$,
  - $U_{2013} = e^{-6\delta}$,
  - $U_{2014} = e^{-5\delta}$, and

- $U_{2015} = e^{-4\delta}$

δ is assumed to be 0.3.

The model fits to the CPUE index and the resultant biomass indices for these two hypotheses are shown in Figure 1.

The fits conducted were not taken through to full minimisation – rather *r* values were estimated and times at which changes occurred were chosen that were considered realistic and provided a reasonable reflection of the main trends in the CPUE data. Thus, for example, the fact that the *r* value for the catchability change scenario was estimated on the constraint boundary of 0.4 has not immediately been taken further. The objective at this stage is simply to ensure that the model does capture the broad range of alternative explanations for the recent CPUE trend in the fishery.

Forward Projections

Hypotheses 1 and 2 were projected deterministically 20 years into the future for the following two Scenarios:
<u>Scenario A</u>: project forward from the same levels as for Z_y or U_y as estimated for 2015
<u>Scenario B</u>: project forward, allowing Z_y for Hypothesis 1 to increase back to 1 by 2017 and U_y for Hypothesis 2 to increase back to 1 by 2019.

The two scenarios described above are depicted graphically in Figures 2 and 3 respectively.

For the analyses conducted in 2014 options for future effort levels (E_y) applied in the projections were to reflect a decrease in effort phased down steadily over three years with the reference effort level taken to be that of 2013. For the updated analyses the following future effort levels have been considered:

$E_{2016} = E_{2013}$,
$E_{2017} = (1 - a)E_{2013}$,
$E_{2018} = (1 - 2a)E_{2013}$, and
$E_{2019+} = (1 - 3a)E_{2013}$

Values of a for which results are reported are 0 (i.e. no phase down from 2013 level), 0.2, and 0.3.

Results and Discussion

Results from the application of Scenarios A and B for Hypothesis 1 (related to a change in catchability) are shown in Figure 4 while those for Hypothesis 2 (related to a change in productivity) are shown in Figure 5 (and magnified for Scenario A in Figure 6) for the future effort level options specified. A comparison across Hypothesis/Scenario combinations for the each of the a values considered is shown in Figure 7. A comparison of the biomass and catch projections from the assessment conducted in 2014 to those reported in this paper is shown in Figure 8.

Figure 4 indicates that if the data reflect a catchability effect, and whether future levels of catchability remain low or increase, this would not be a cause for concern given that the projected biomass remains at high levels irrespective of the level of future effort (amongst the options considered) that is applied.

Figure 5 indicates that if the data reflect a productivity effect and the future extent of this effect remains low (Scenario A), biomass, catches and CPUE would decline for a=0, but remain virtually stable for a=0.2 and increase slightly for a=0.3 (these trends have been magnified in Figure 6 to provide better contrast between the various a options). For the scenario where U_y returns to 1 by 2019 the projected biomass shows an increasing trend for all future effort options, and both catches and CPUE increase even for the most pessimistic scenario of future effort.

Comparisons of the Hypothesis/Scenario combinations for each of the future effort levels tested are shown in Figures 7. Across the a options, a=0.3 would be best to ensure biomass recovery if biomass is indeed low, but this is at the expense of future catches, which would become very low.

Figure 8 compares the projected biomasses and catches from the 2014 and 2016 assessments for the most pessimistic of the Scenarios (Scenario A for the Productivity Hypothesis). These indicate less pessimistic results from the updated (2016) assessment, given that projected biomass levels are higher than those from the 2014 assessment ,and for two of the a options biomass is relatively stable or increasing, whereas previously biomass was estimated to be decreasing for all options of a. Similarly, projected catches are also higher for the 2016 assessment compared to those from the 2014 assessment.

References

Butterworth, D.S. and Glazer, J.P. 2014. A preliminary assessment of the South African east coast sole resource, *Austroglossus pectoralis*. Unpublished DAFF working Group Document: Fisheries/2014/OCT/SWG-DEM/63. 12pp.

Fairweather, T.P., Glazer, J.P., and Durholtz, M.D. 2016. Summary of Agulhas sole CPUE analyses. Unpublished DAFF working Group Document: Fisheries/2016/AUG/SWG-DEM/38. 5pp.

Table 1: Catch (tons) and standardized CPUE (kg/minute) used in the Schaefer assessment model. (Source: Catch - Fairweather (pers. commn); CPUE – Model Cb of Fairweather *et al*, 2016).

	Catch (t)	CPUE(kg/min)
2000	1060	1.44
2001	850	1.47
2002	702	1.00
2003	754	1.03
2004	612	1.05
2005	485	0.95
2006	428	1.02
2007	331	0.92
2008	448	0.95
2009	568	1.40
2010	570	1.16
2011	436	1.11
2012	338	0.79
2013	127	0.39
2014	208	0.62
2015	258	0.71

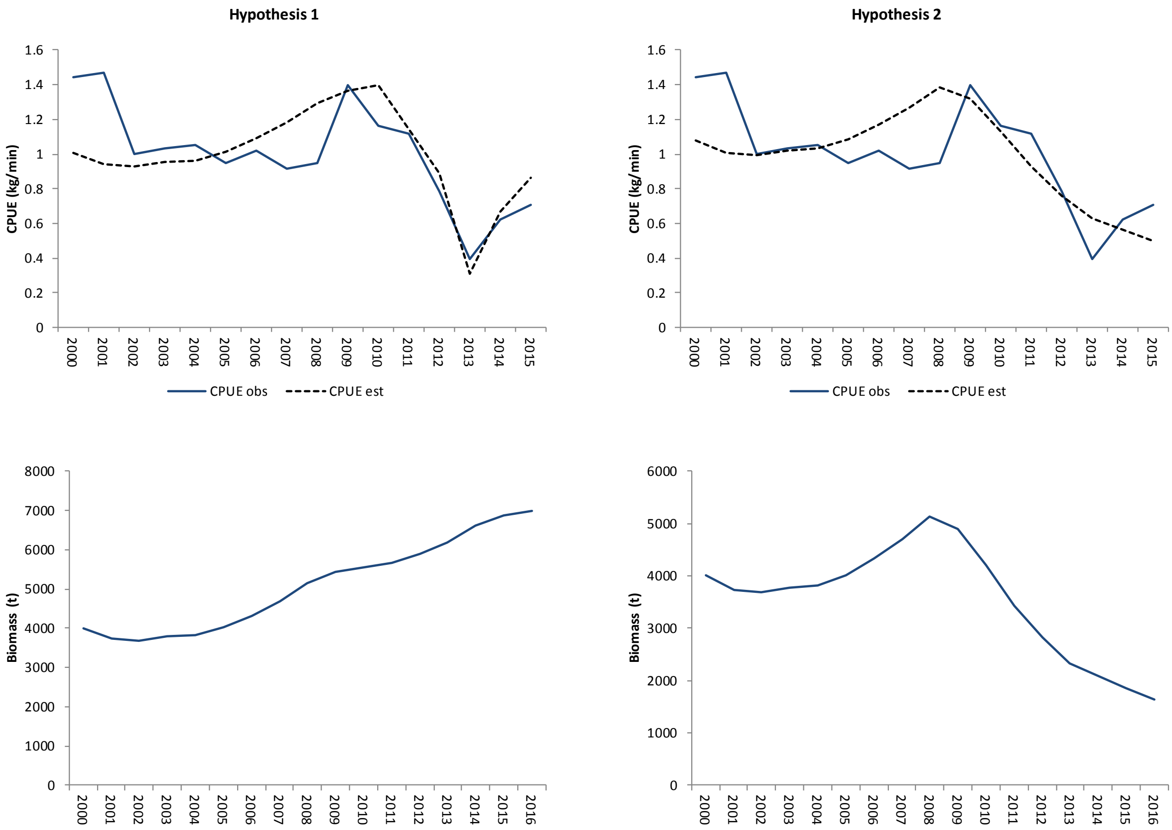


Figure 1: Fits to the CPUE data (top panel) and the biomass trends (lower panel) for Hypothesis 1 (a reduction in catchability) and Hypothesis 2 (a reduction in productivity) respectively.

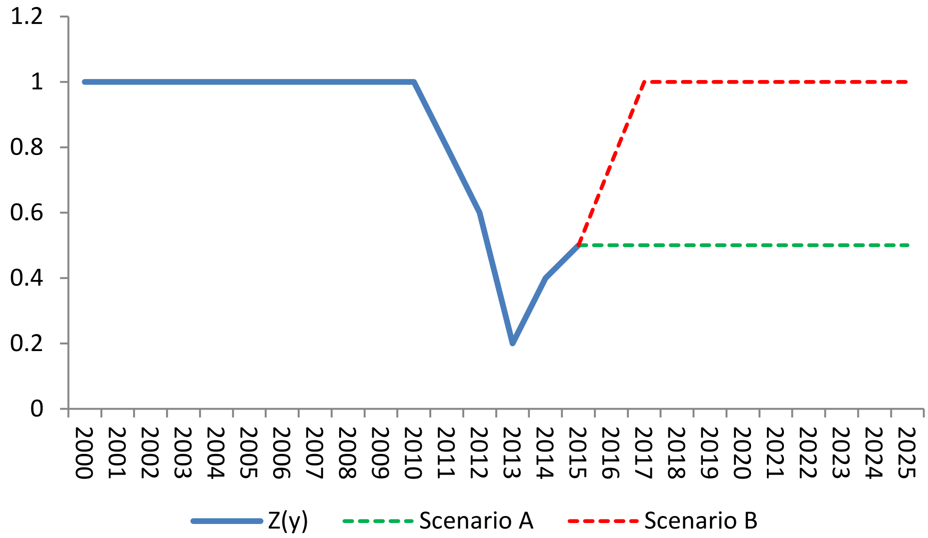


Figure 2: Scenarios A and B for projections related to Hypothesis I: catchability has decreased by 60% over 2010-2013, after which it remains at the same level as for 2015 or increases back to a relative value (*Z*(*y*)) of 1 by 2017.

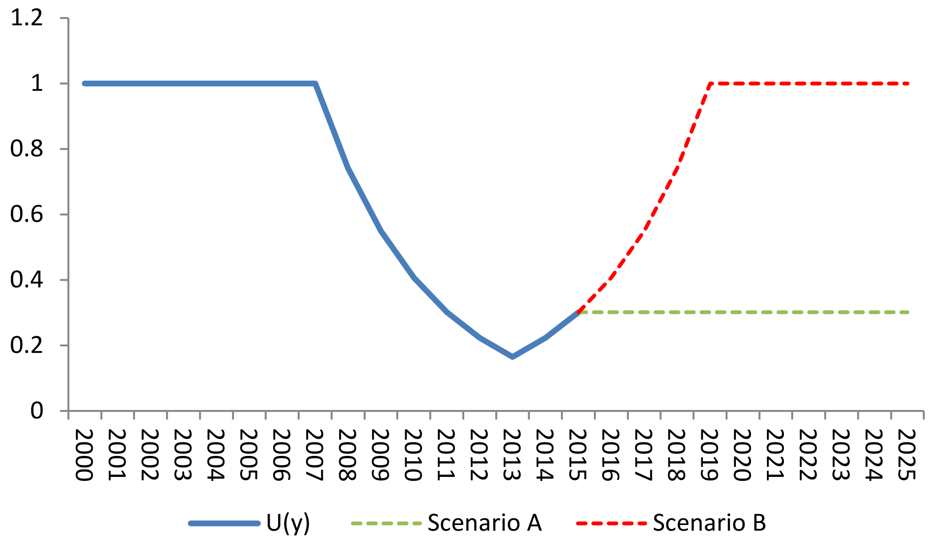


Figure 3: Scenarios A and B for projections related to Hypothesis II: productivity has dropped by 85% over 2008-2013, after which is remains at the same level as 2015 or increases back to a relative value (*U*(*y*)) of 1 by 2019.

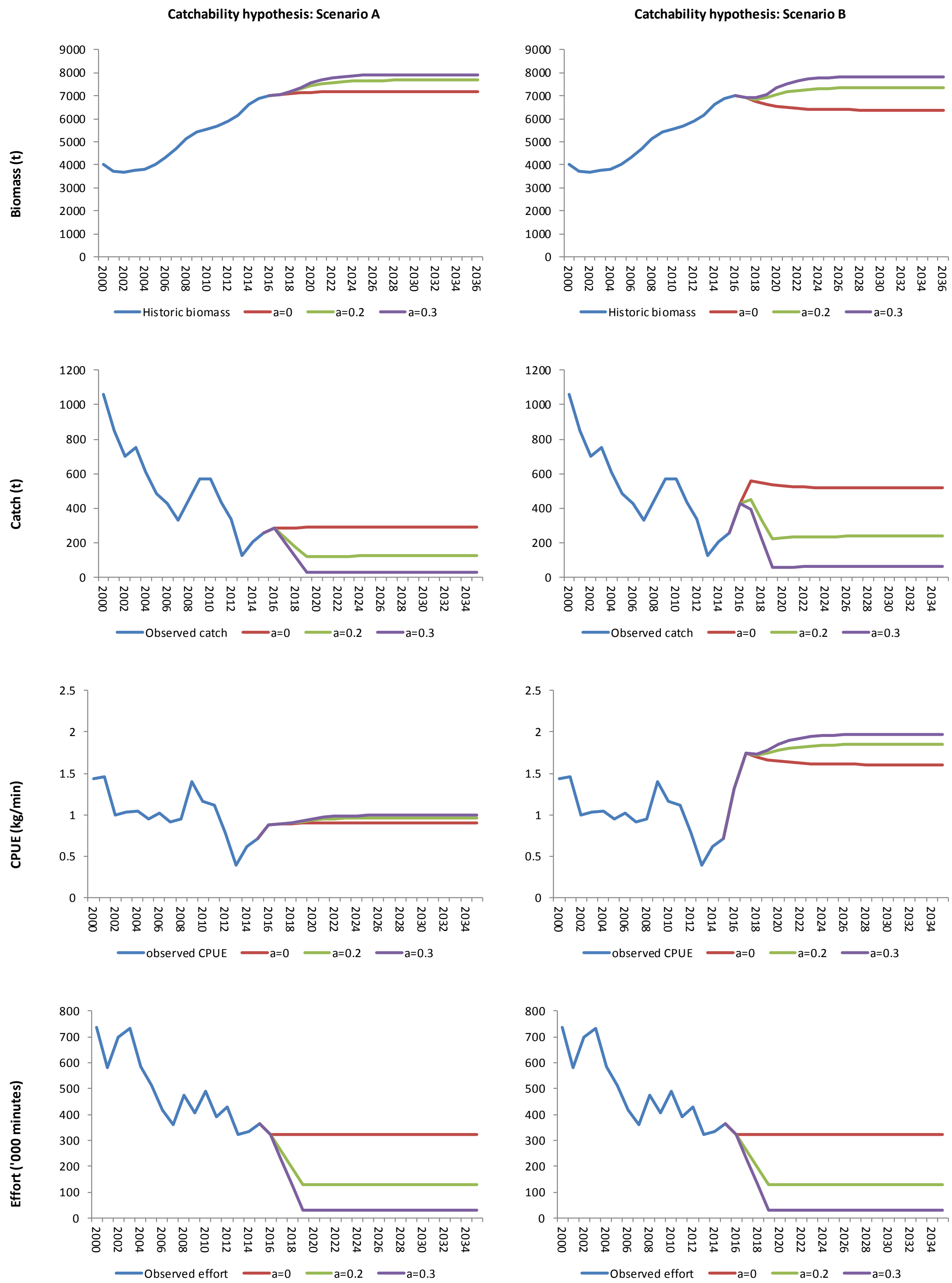


Figure 4: Projected biomass, catch and effort for Hypothesis 1: catchability has decreased by 60% over 2010-2013 for Scenario A (no change from 2015 value – left side plots) and Scenario B (back to normal by 2017 – right side plots) for different future effort reduction levels.

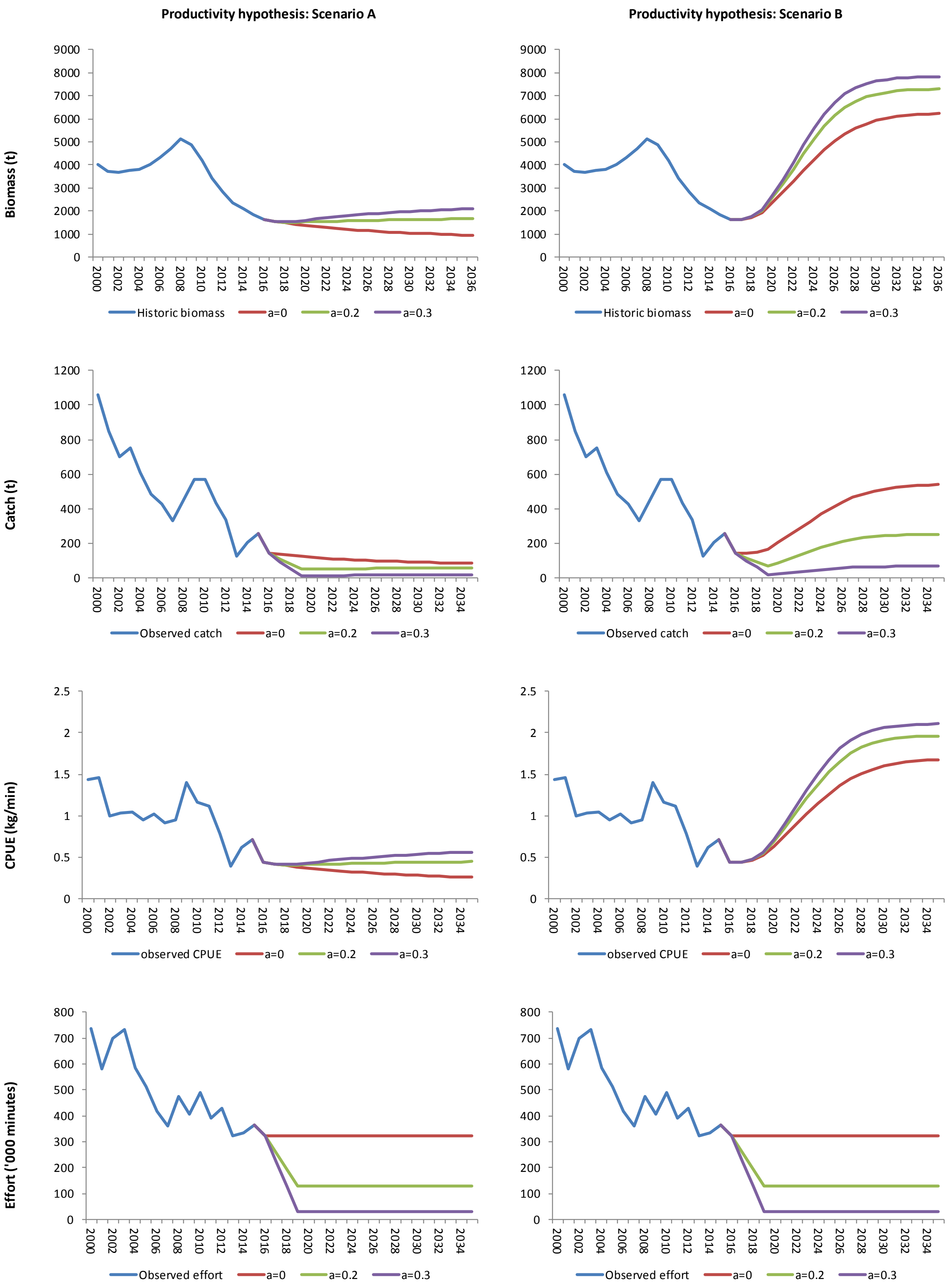
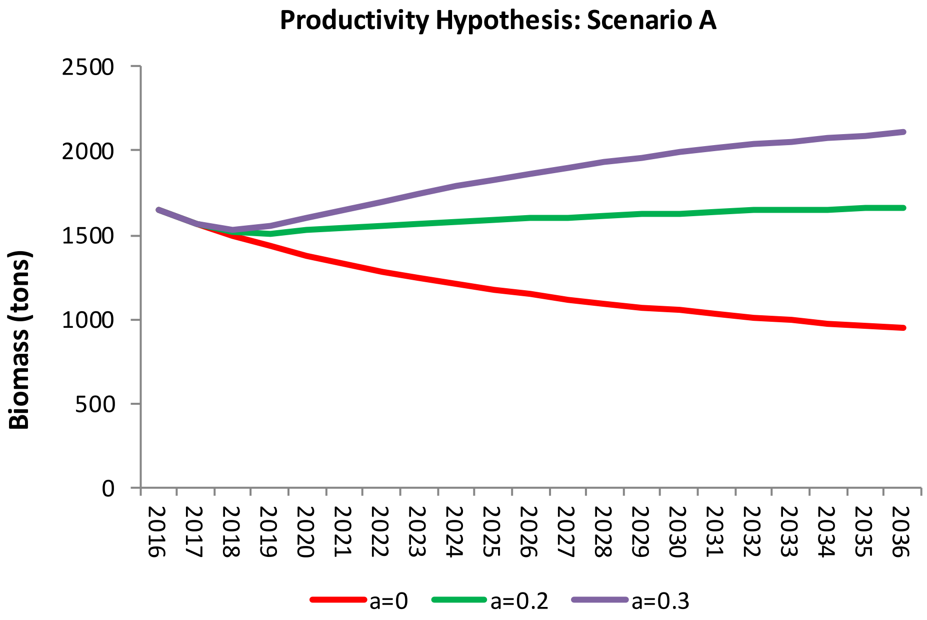


Figure 5: Projected biomass, catch and effort for Hypothesis 2: productivity has dropped by 85% over 2008-2013 for Scenario A (no change from 2015 – left side plots) and Scenario B (back to normal by 2019 – right side plots) for different future effort levels.



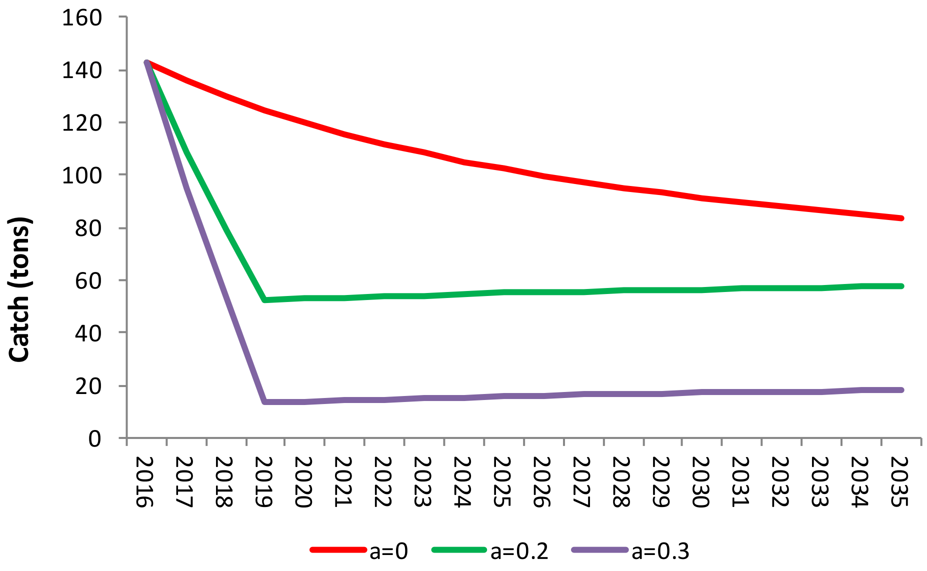


Figure 6: Magnification of the Biomass and Catch projections for Scenario A of Figure 5 for the Productivity Hypothesis for the projection period only, to allow for clearer differentiation between the alternative future effort scenarios.

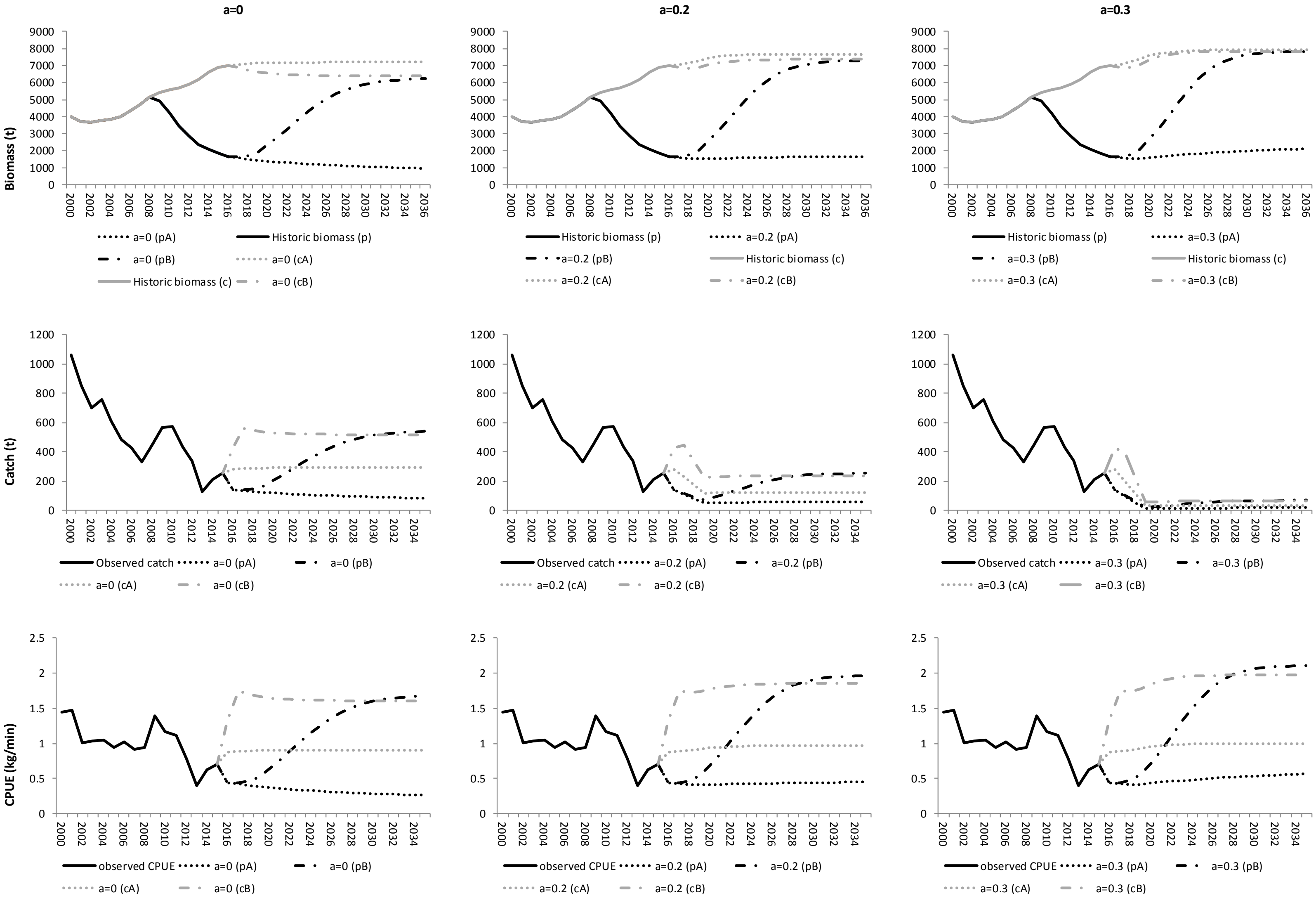
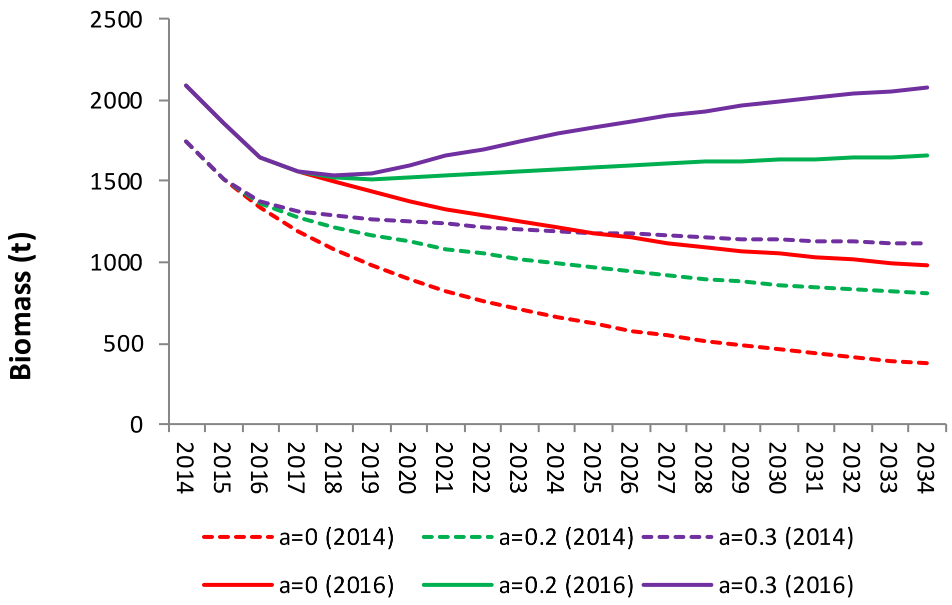


Figure 7: Comparisons across a=0, a=0.2, and a=0.3 (different future effort levels) for the two hypotheses. "pA" and "cA" refer to the productivity and catchability hypotheses respectively where for the future projections levels remain at those of 2015. "pB" and "cB" refer to the productivity and catchability hypotheses respectively where for the future projections the multiplier factor Z(y) returns to 1 by 2017 and the factor U(y) returns to 1 by 2019.



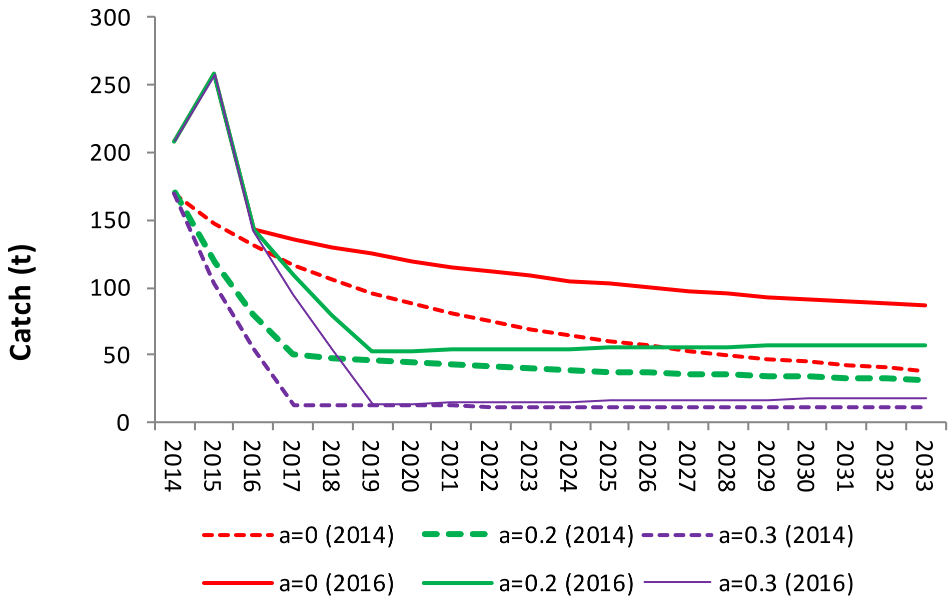


Figure 8: A comparison of the projected biomasses and catches for Scenario A (no change) of the Productivity Hypothesis for the assessments conducted in 2014 and 2016 respectively. Note that the catches for 2014 and 2015 for the 2016 assessment scenarios are the actual catches that occurred since the updated assessment includes data to 2015.